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TIBIAL FRACTURE AFTER UNICOMPARTMENTAL KNEE REPLACEMENT: THE IMPORTANCE OF SURGICAL CUT ACCURACY

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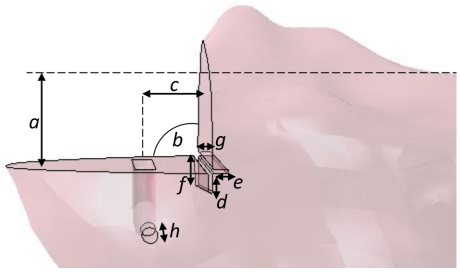
Introduction and Objectives: Tibial fracture is a possible complication after unicompartmental knee replacement (UKR) which can have severe consequences for patient recovery and outcome [1]. It appears that the issue is not product specific, as peri-prosthetic fractures have been reported in numerous designs, both mobile and fixed. However, it has been suggested that cementless components might be at greater risk than cemented [2]. The exact causes of tibial fracture are unknown, although surgical factors are most commonly proposed in the literature [1,3].
The objectives of the study were to; (1) determine the range of positions and depths of the surgical cuts required to prepare the tibial plateau for a UKR, (2) use the measured parameters to create a representative range of finite element models, (3) statistically assess the influence of each surgical parameter on the risk of fracture.

Methods: Tibial plastic Sawbones (n=23) were prepared for mobile UKR during an instructional course. The parameters measured from the sawbones were: (a) the resection depth, (b) the angle between the horizontal and vertical cuts, (c) the distance between the vertical wall and the keel slot, how excessively deep the vertical cut and horizontal cuts were anteriorly (d and e, respectively), and posteriorly (f and g, respectively), and (h) the depth of the pin hole (Figure 1).
A parametric finite element model was created in ABAQUS software (v6.12, Dassault Systèmes) with an automated python script to create the surgical cuts. One hundred models were created, where the surgical cut parameters were varied within the distributions measured from the Sawbones. A mesh element size of 2.4 mm was used, selected as a result of a mesh convergence study. The tibia was modelled as a heterogeneous linear elastic material, with a Poisson's ratio of 0.3. The modulus of each element was assigned based upon the corresponding position of that element in the CT scan of the tibia. The equations used for this have been previously defined and the tibial model validated [4]. Muscle and joint loading of a tibia at 15% of the gait cycle was applied, corresponding to maximal medial contact force, and the distal portion of the tibial constrained in all degrees of freedom. The risk of fracture was quantified based upon the Maximum Principal Stress criterion equations defined by Schileo et al. [5].
The influence of each surgical parameter on the risk of fracture was assessed using linear regression with R (r-project).

Results: In the tibial Sawbone measurements, the greatest surgical variation was observed in the depth of the posterior vertical cut and the pin hole, which had standard deviations of 3.9 and 6.8 mm respectively (Table 1).

The only surgical cut parameters which were found to significantly affect the risk of fracture were the resection depth, and the posterior depth of the vertical cut ($p=0.009$, and $p=0.000001$, respectively).
Some finite element models demonstrated a noticeable region at high risk of fracture, which extended diagonally from the vertical saw cut, past the base of the keel slot to the tibial cortex. This matched well with typical fracture paths observed clinically [1].

Figure:



Caption: Figure 1. The surgical cut parameters made on a right Sawbone tibia which were recorded were: the resection depth (a), the angle between the horizontal and vertical cuts (b), the wall to keel distance (c), how excessive the vertical and horizontal cuts were anterior (d, e) and posterior (f, g), and the depth of the pin hole for fixing the cutting guide (h).

Conclusion: This study has shown accuracy in the depth of the vertical cut made to prepare the tibial plateau for UKR, has the greatest clinical variation and has the greatest influence on the risk of fracture out of all the parameters assessed in this study. It is therefore important that instrumentation be designed to improve surgical accuracy for this part of the operative technique.

Table:

Parameter	Mean	Standard Deviation
A: Resection Depth (mm)	8.8	1.7
B: Angle between cuts (deg)	90.6	1.4
C: Wall to keel distance (mm)	8.5	0.7
D: Anterior depth vertical cut (mm)	0.5	1.0
E: Anterior depth horizontal cut (mm)	0.7	0.9
F: Posterior depth vertical cut (mm)	4.2	3.9
G: Posterior depth horizontal cut (mm)	1.3	2.1
H: Depth of pin hole (mm)	28.6	6.8

Caption: Table 1. Summary of the measured surgical cut parameters from Sawbones prepared during an instructional course

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Disclosure of Interest: E. C. Pegg Conflict with: Biomet, H. G. Pandit Conflict with: Biomet, H. S. Gill Conflict with: Biomet; Smith & Nephew; Stryker, Conflict with: Smith & Nephew, D. W. Murray Conflict with: Bluebelt Technologies, Conflict with: Biomet; Stryker; Zimmer, Conflict with: Biomet